Spatial and temporal scales of variability in the productivity of Northeast Pacific fish stocks

Franz J. Mueter[1], Jennifer Boldt[1], Bernard A. Megrey[2], and Randall M. Peterman[3]

1. Joint Institute for the Study of the Atmosphere and the Oceans, University of Washington, Seattle, WA, USA. E-mail: fmueter@alaska.net
2. National Marine Fisheries Service, Alaska Fisheries Science Center, Seattle, WA, USA.
3. School of Resource and Environmental Management, Simon Fraser University, British Columbia, Canada

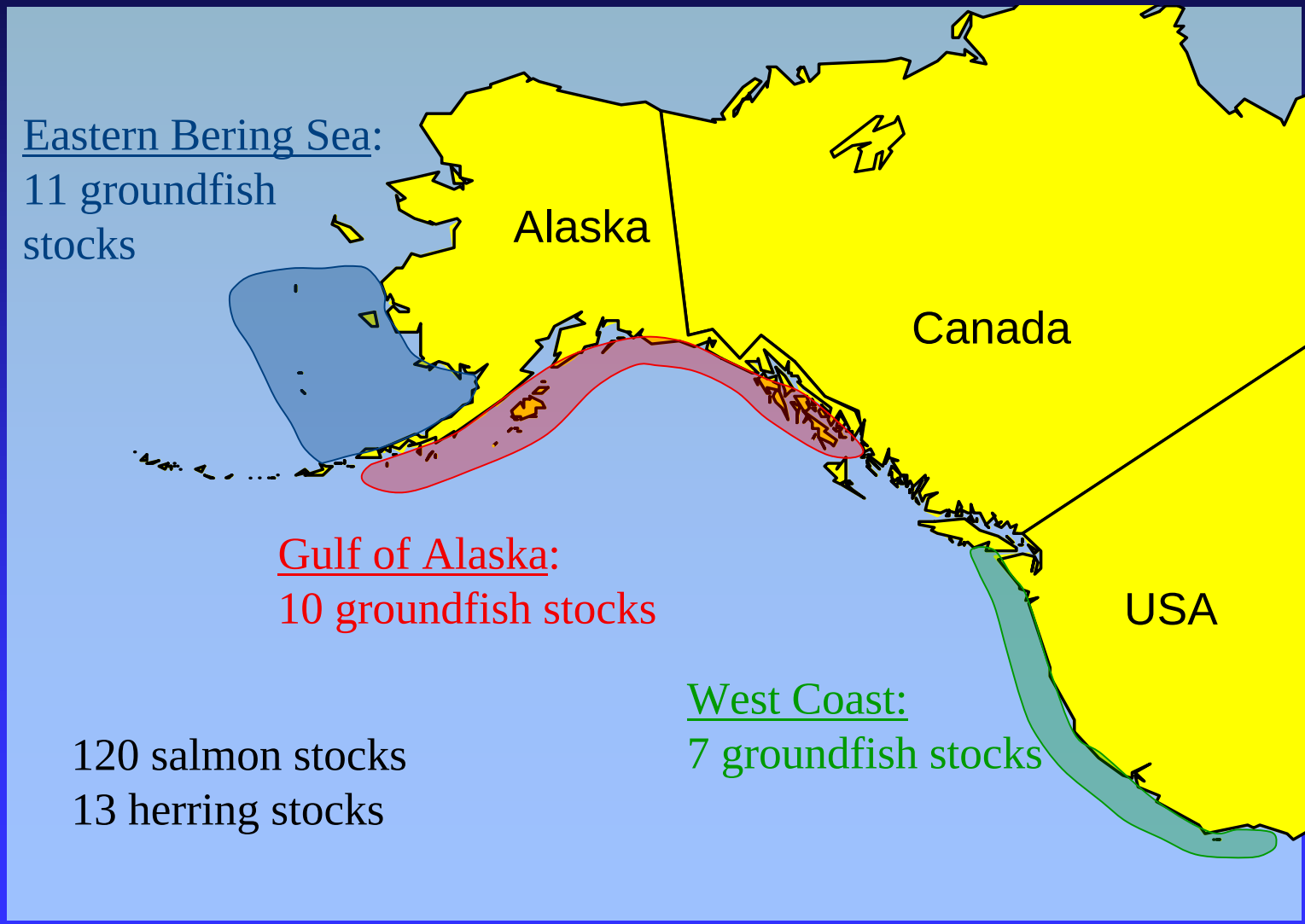
Goals

- Key question: “At what spatial and temporal scales are physical processes most important in affecting marine fish populations?”
- Spatial and temporal scales of variability
  - physical environment
  - Dynamics / productivity of marine fish populations
- Objective: Characterize spatial and temporal scales of variability of Northeast Pacific fish populations
- Scales of significant spatial covariation provide estimate of dominant scale of environmental influences

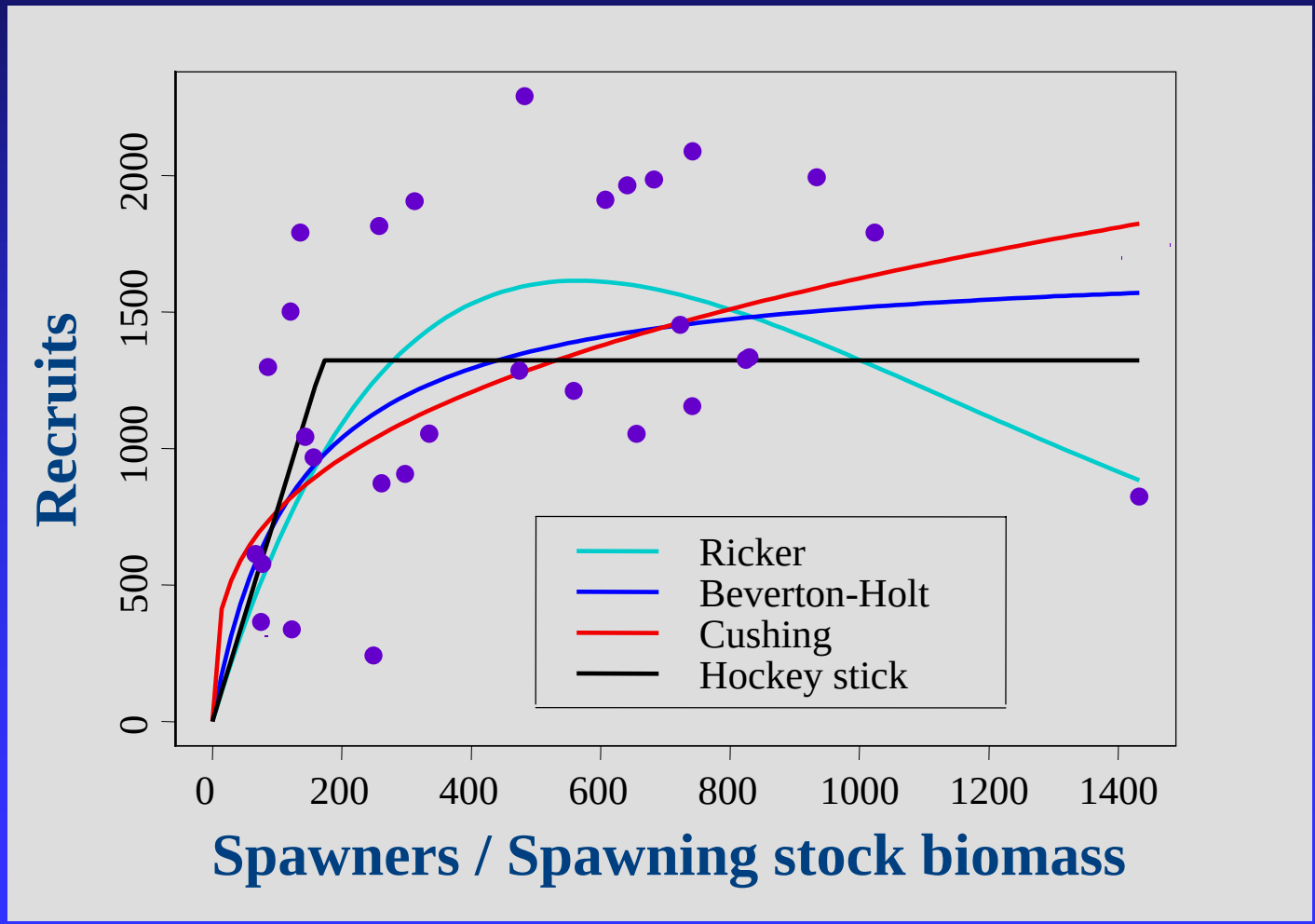
Outline

- Review: Spatial scales of covariation in productivity among salmon populations
- Spatial scales of covariation among herring populations
- Covariation among groundfish populations within & between regions (Bering Sea, Gulf of Alaska, U.S. West Coast)
- Covariation between herring / salmon / groundfish
- Temporal patterns in productivity
- Conclusions

Data

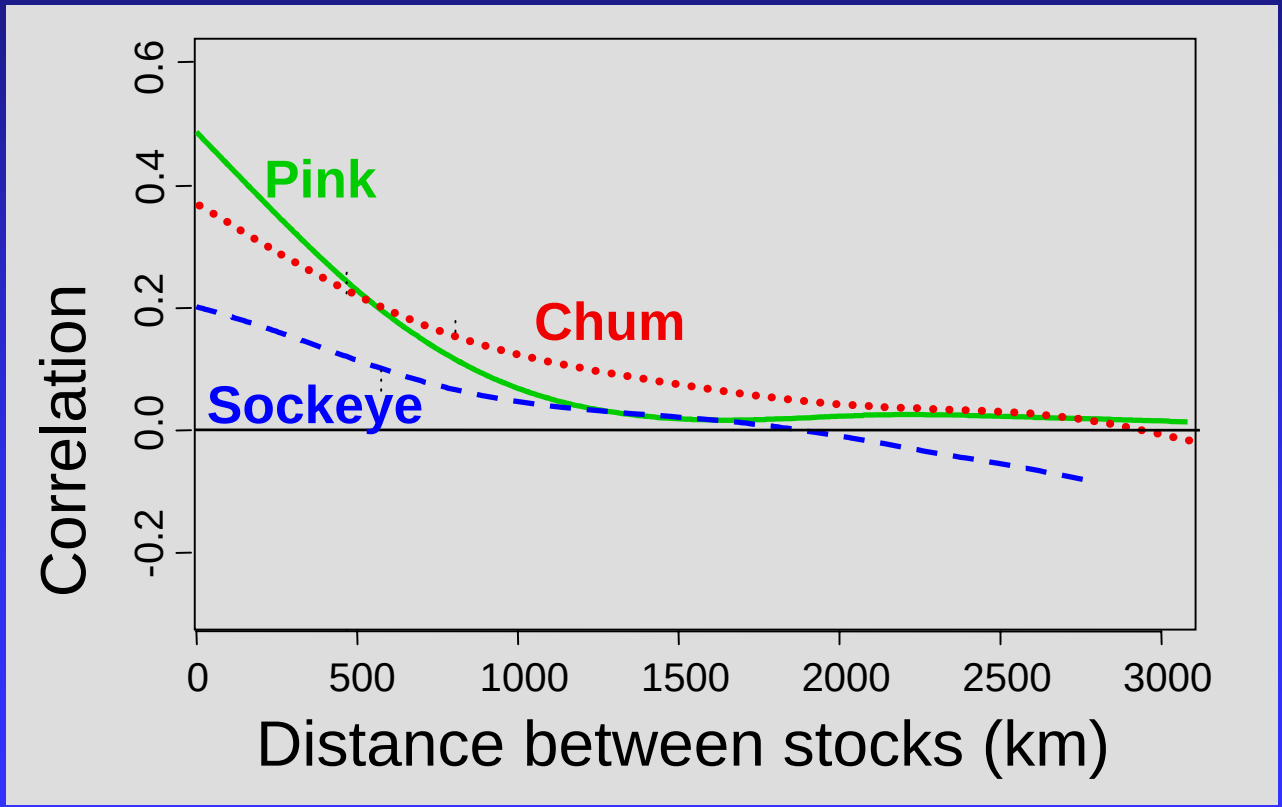

Eastern Bering Sea:
11 groundfish stocks
Alaska
Canada
USA
Gulf of Alaska:
10 groundfish stocks
West Coast:
7 groundfish stocks
120 salmon stocks
13 herring stocks

Stock-recruit residuals as measures of productivity



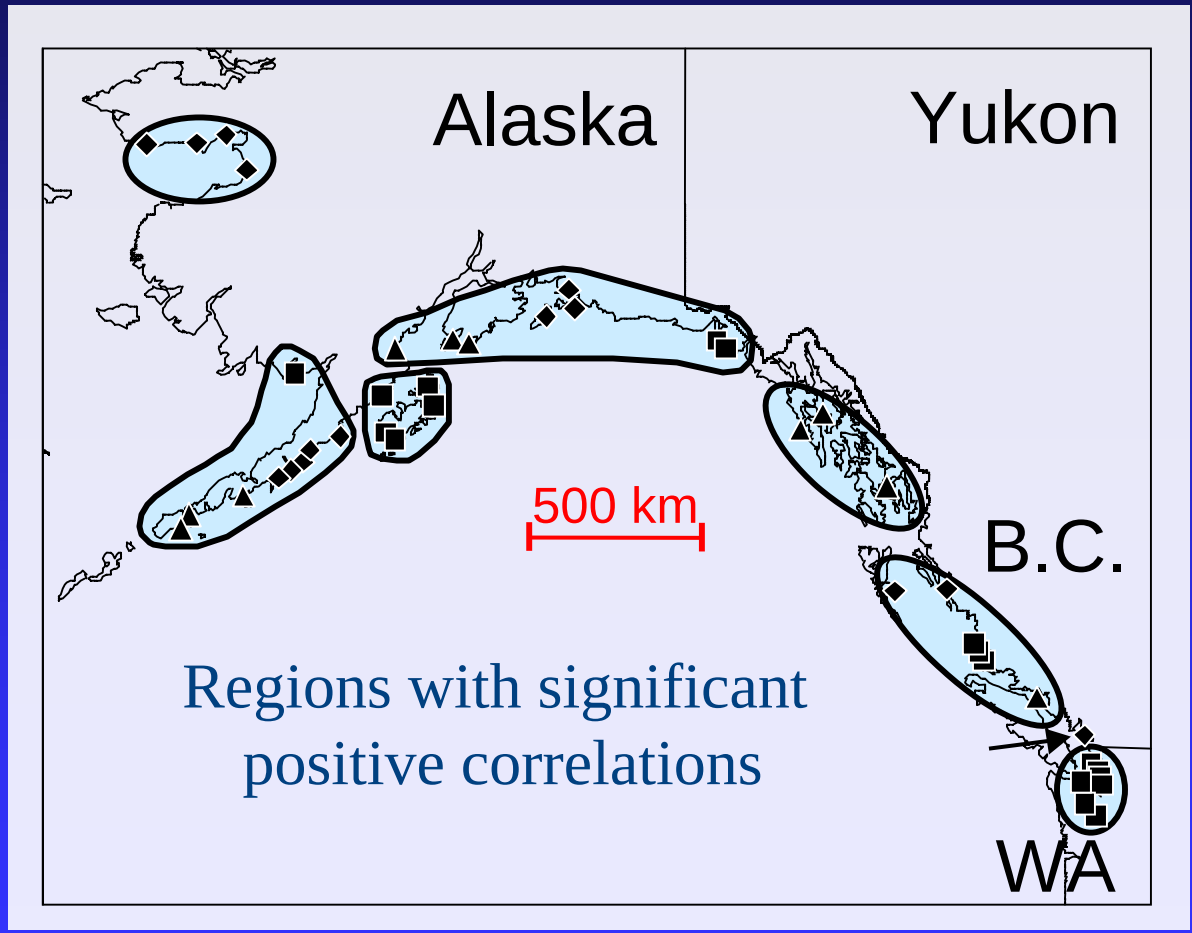
Spatial scales of covariation: Salmon

- Regional covariation in salmon survival rates
- uncorrelated > 800-1000 km



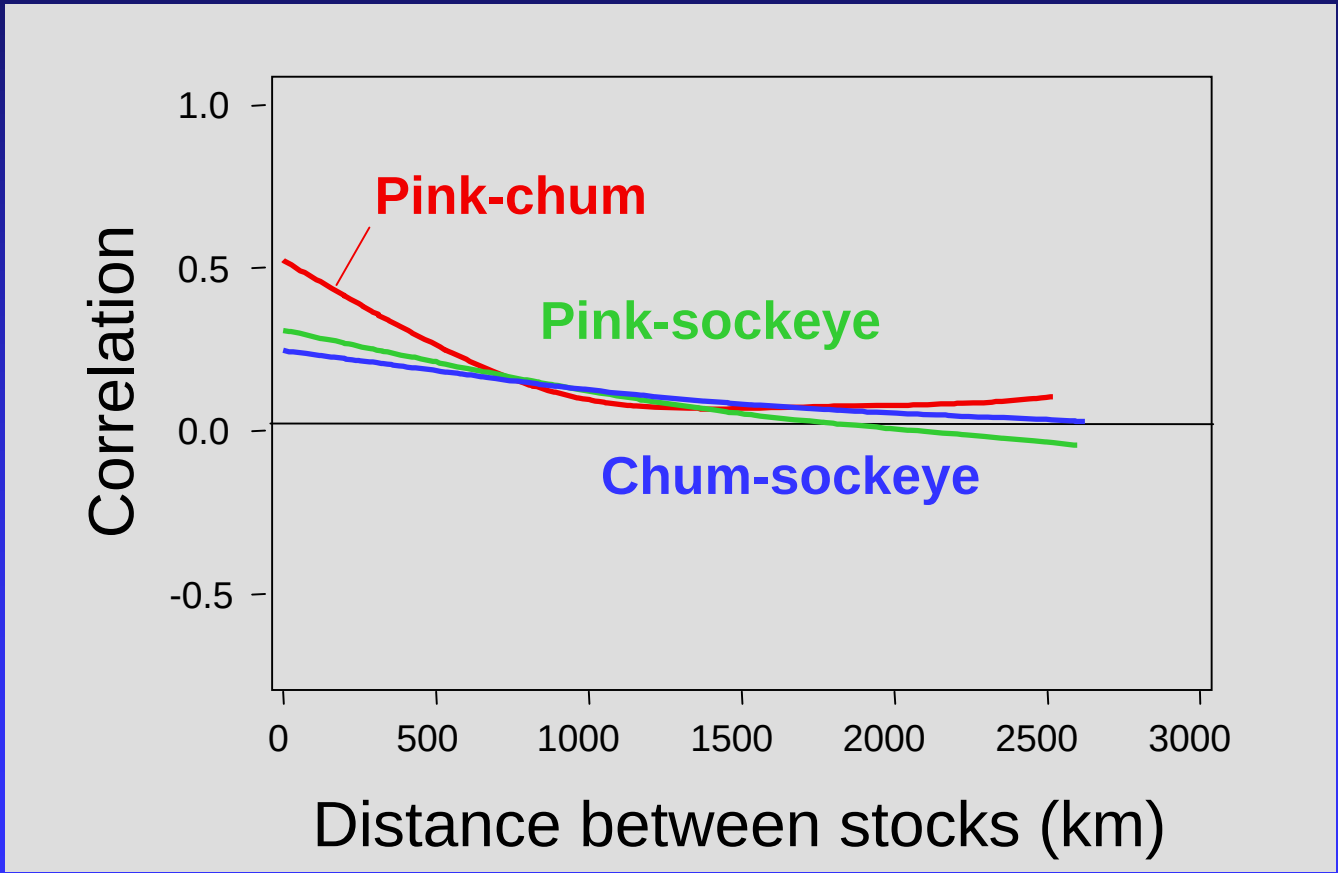
(Mueter et al. 2002, Fish. Oceanogr.)

Spatial scales of covariation: Pink salmon



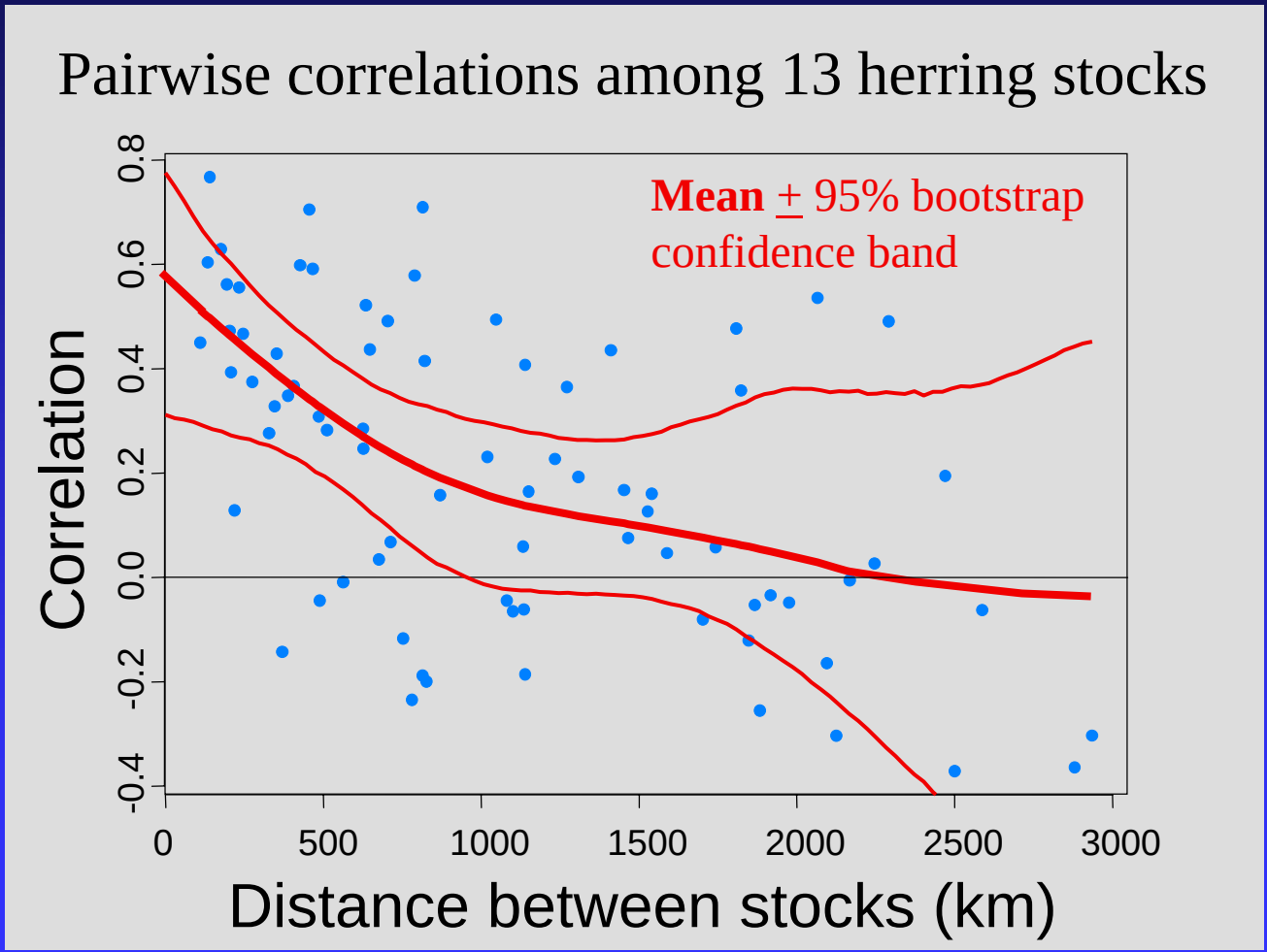
(Pyper et al. 2001, CJFAS)

Cross-species comparisons: 3 salmon species



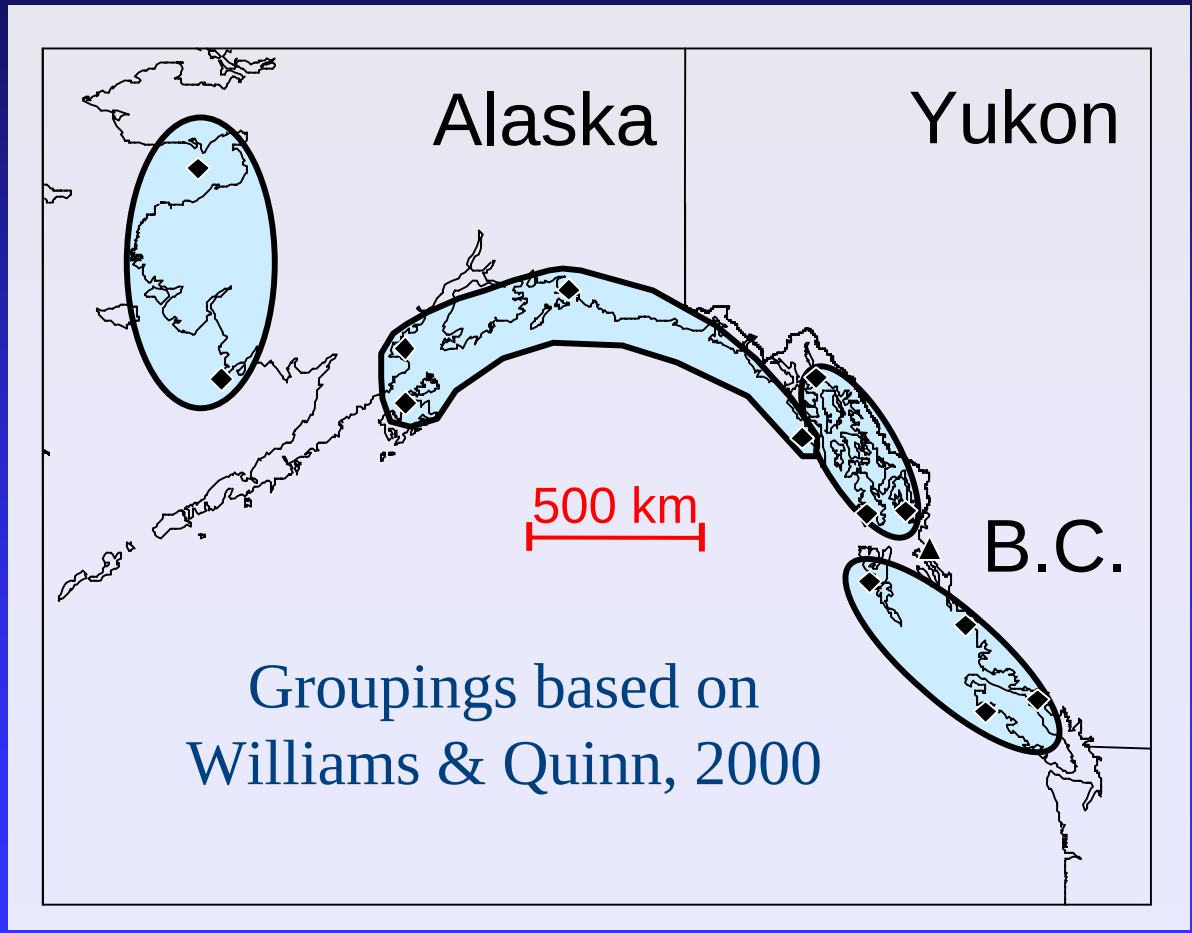
(Pyper et al., 2005, TAFS)

Spatial scales of covariation: Herring

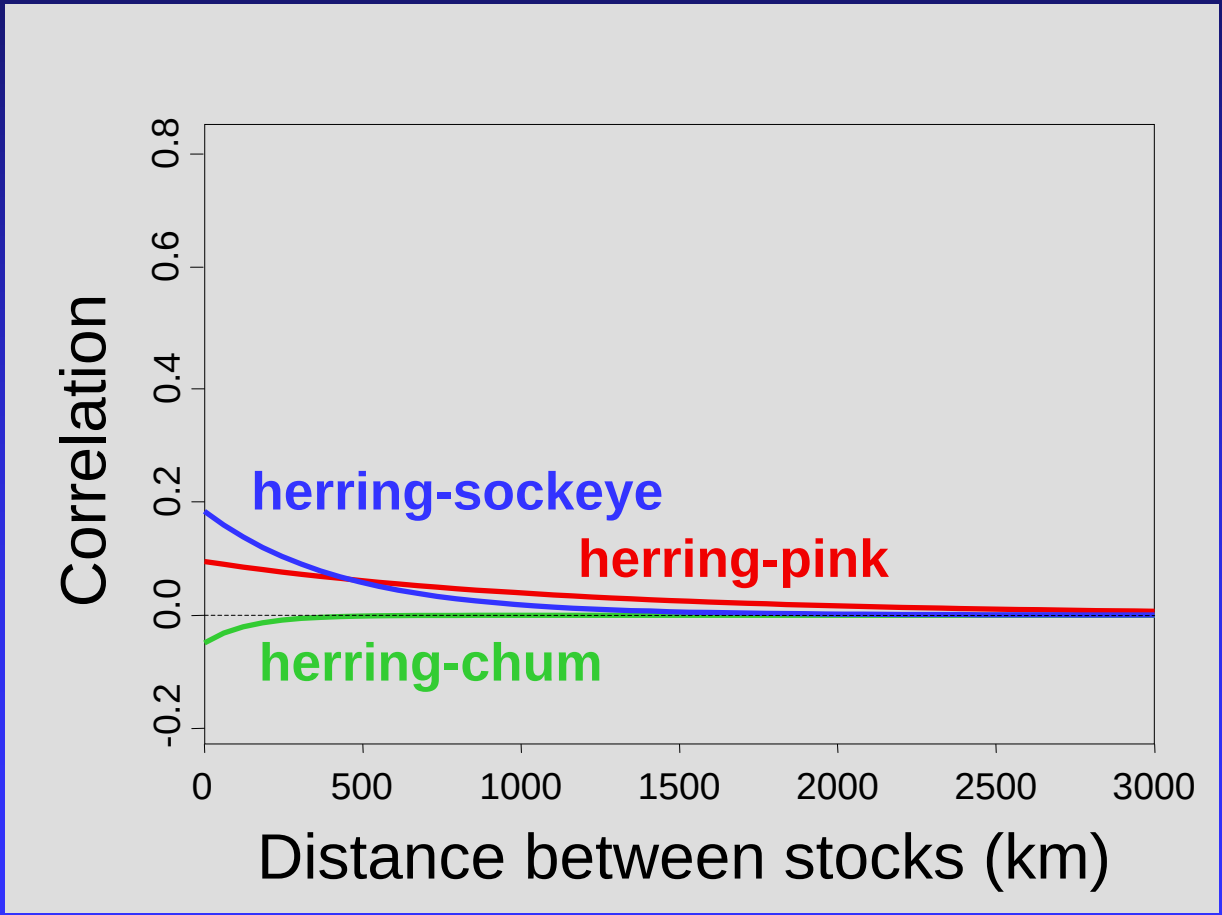


(data from Williams & Quinn 2000)

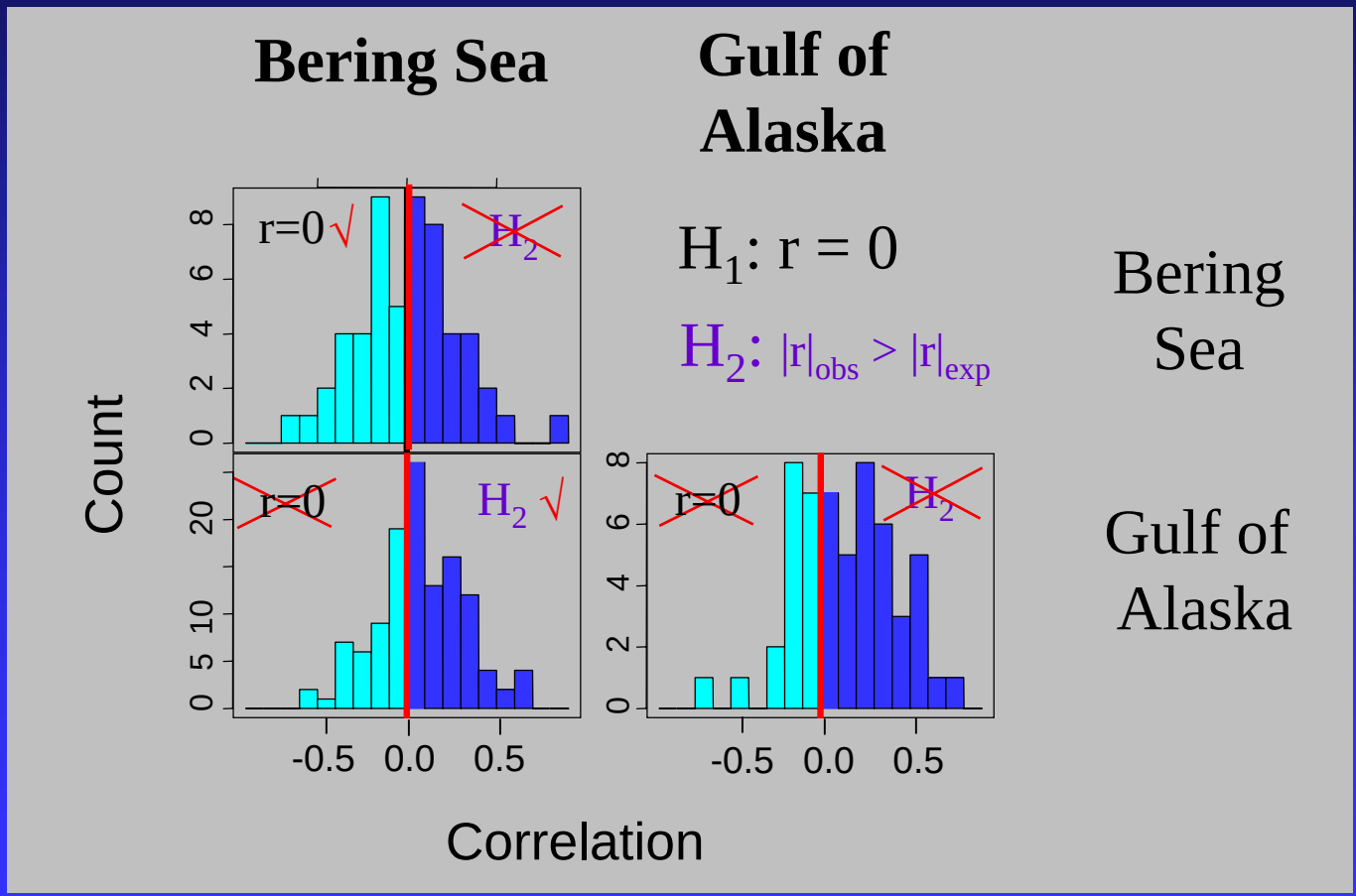
Spatial scales of covariation: Pacific herring



Spatial scales of covariation: Herring vs. salmon



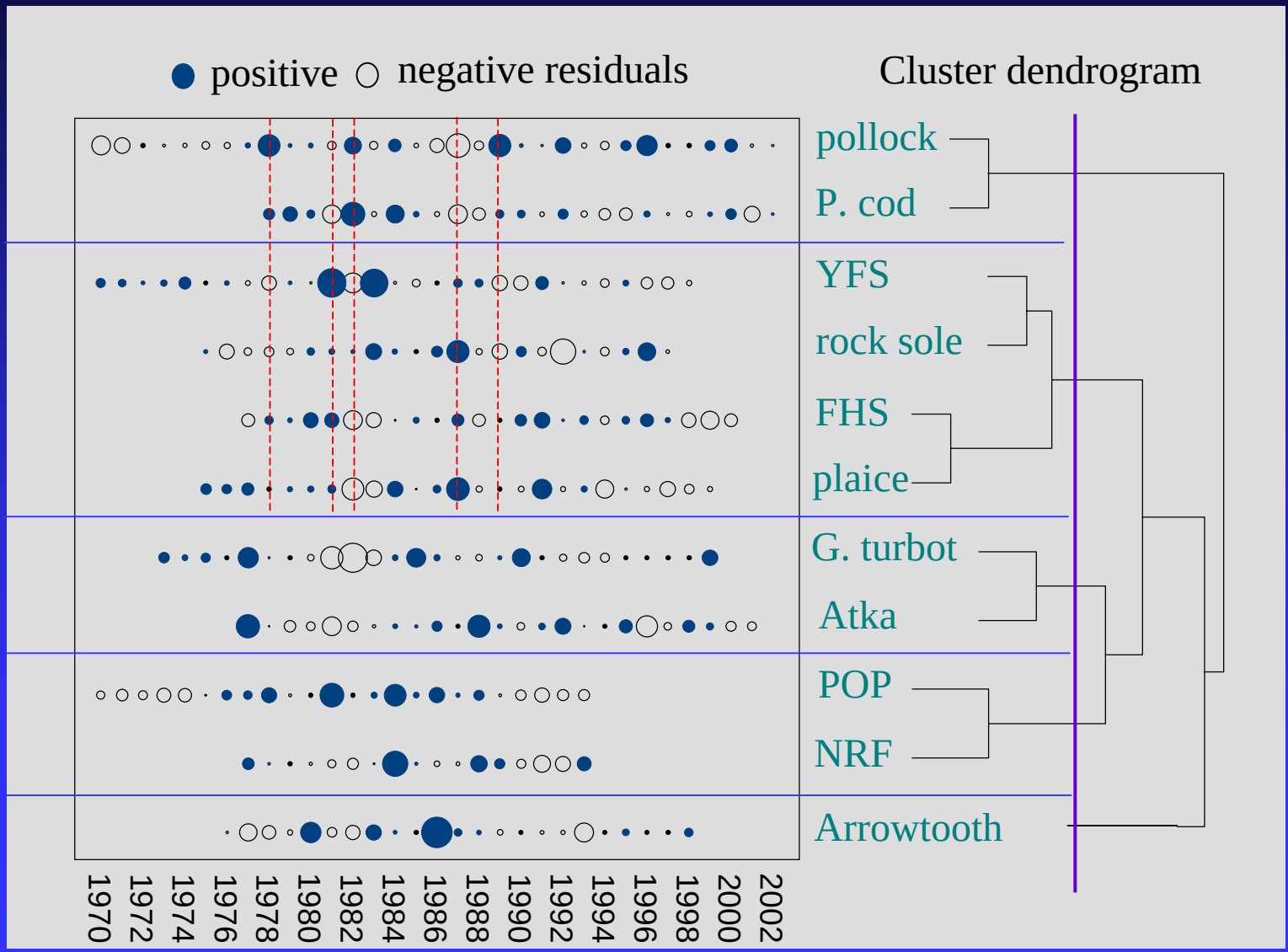
Correlations among stock-recruit residuals: groundfish



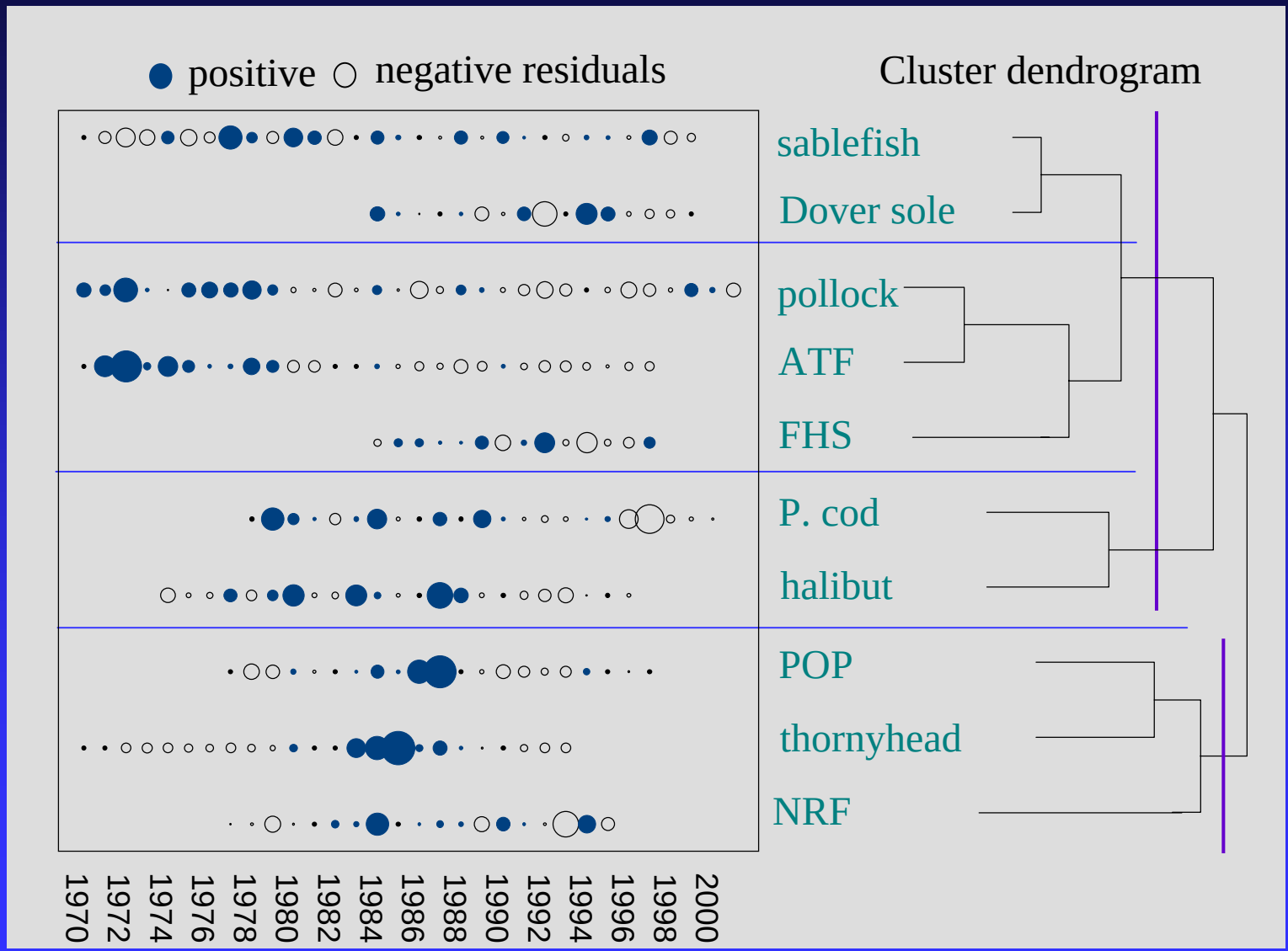
Correlations by species

- Bering Sea vs. Gulf of Alaska
  - Walleye pollock: - 0.021
  - Pacific cod 0.026
  - Arrowtooth flounder - 0.249
  - Flathead sole - 0.003
  - Pacific Ocean Perch **0.464 (p = 0.061)**

Stock-recruit residuals and species clusters: Bering Sea

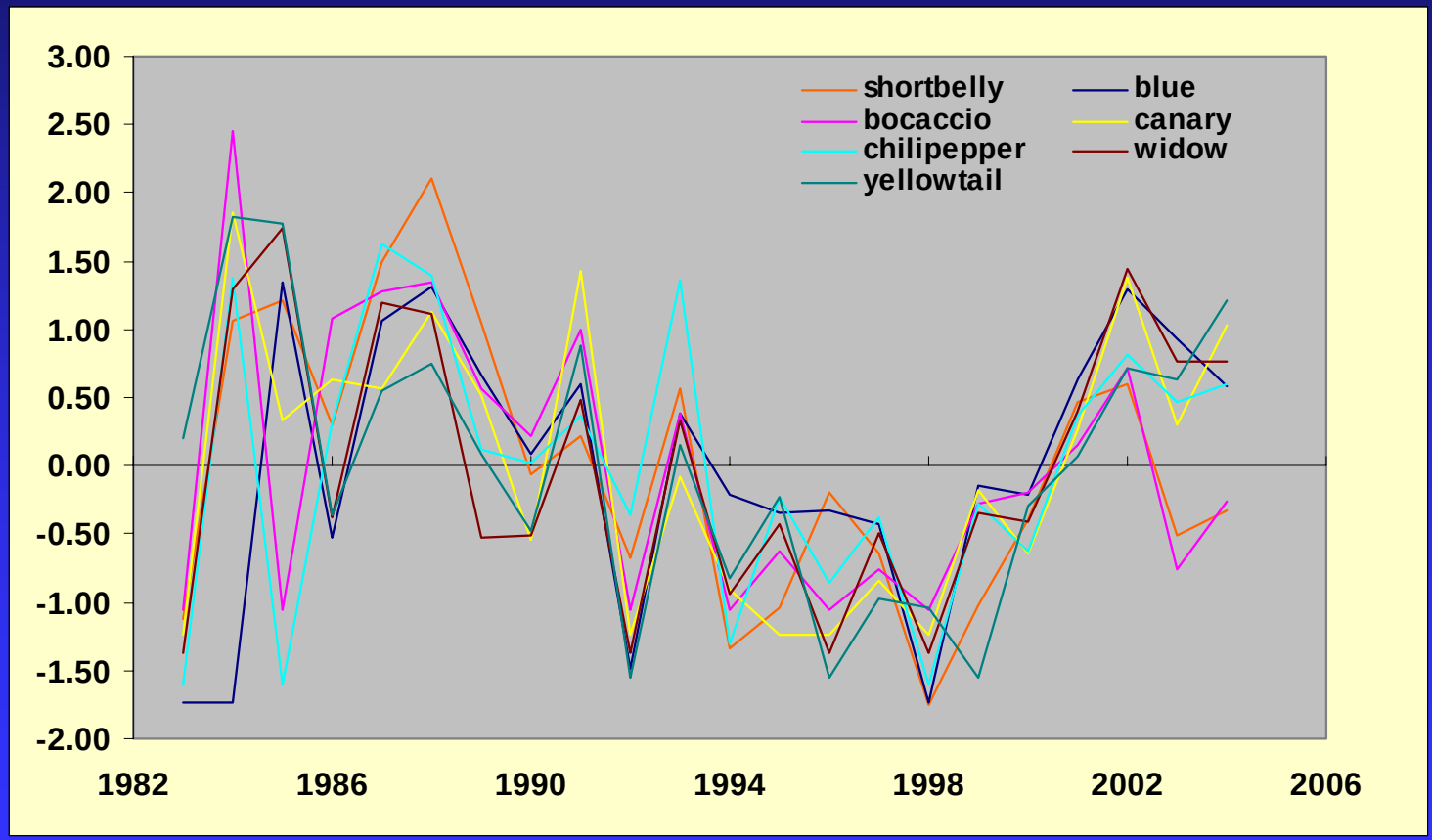


Stock-recruit residuals and species clusters: : Gulf of Alaska



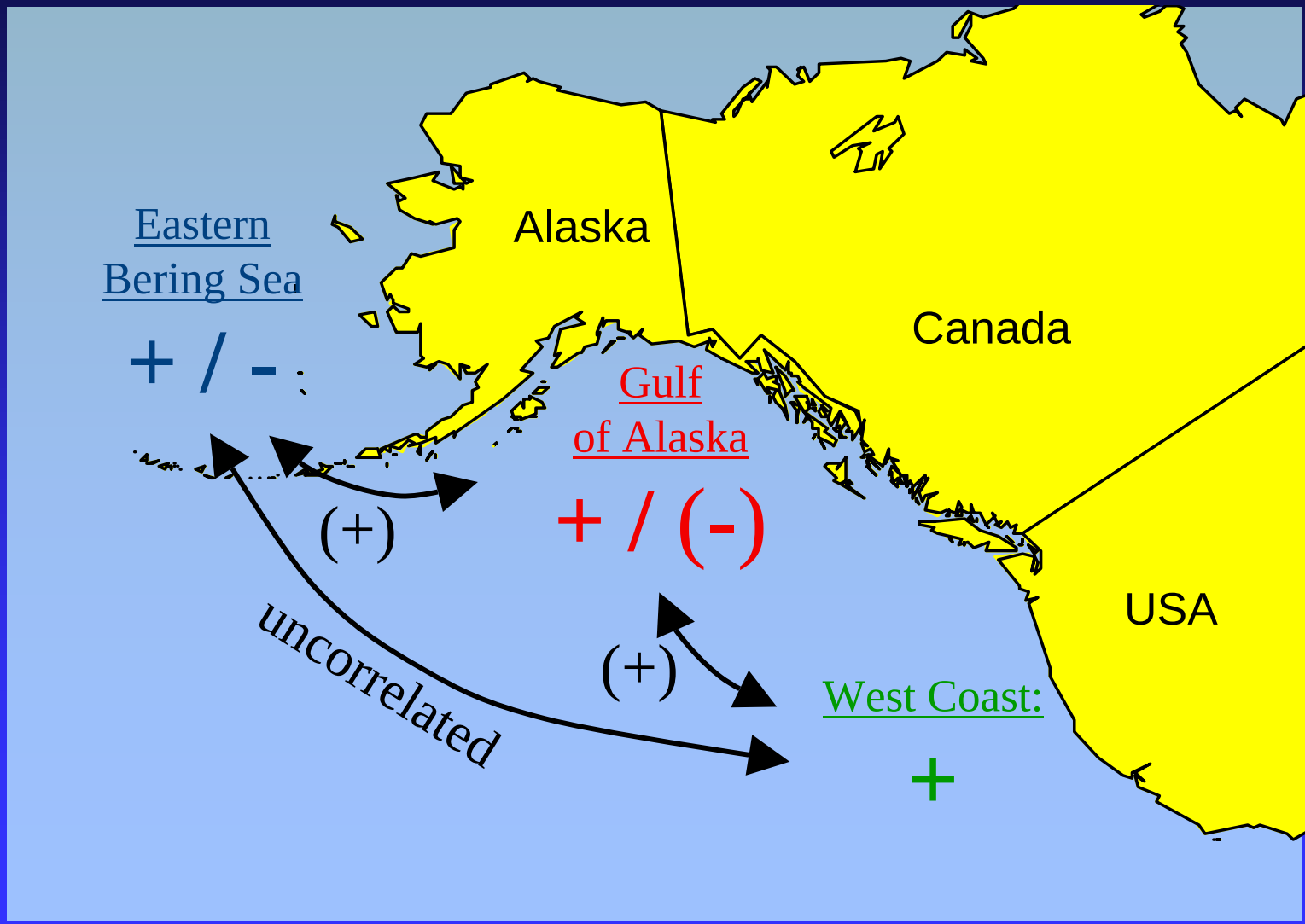
Covariation among West Coast rockfish species

- Relative abundance of 7 species of juvenile rockfish in midwater trawl surveys



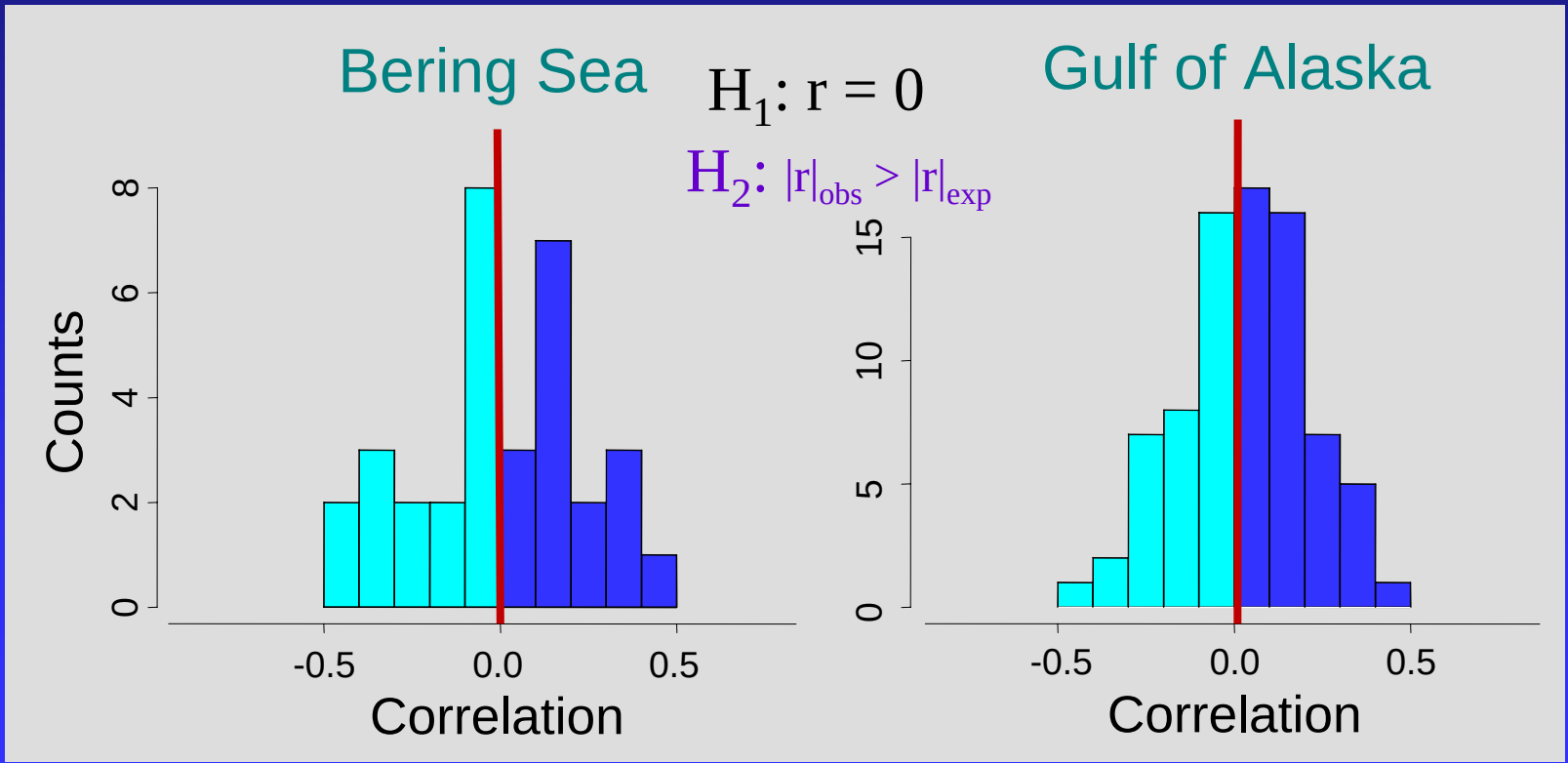
(from J. Field (pers. comm.) based on data from Steve Ralston, SWFSC)

Spatial covariation: groundfish



Covariation: demersal vs. pelagic

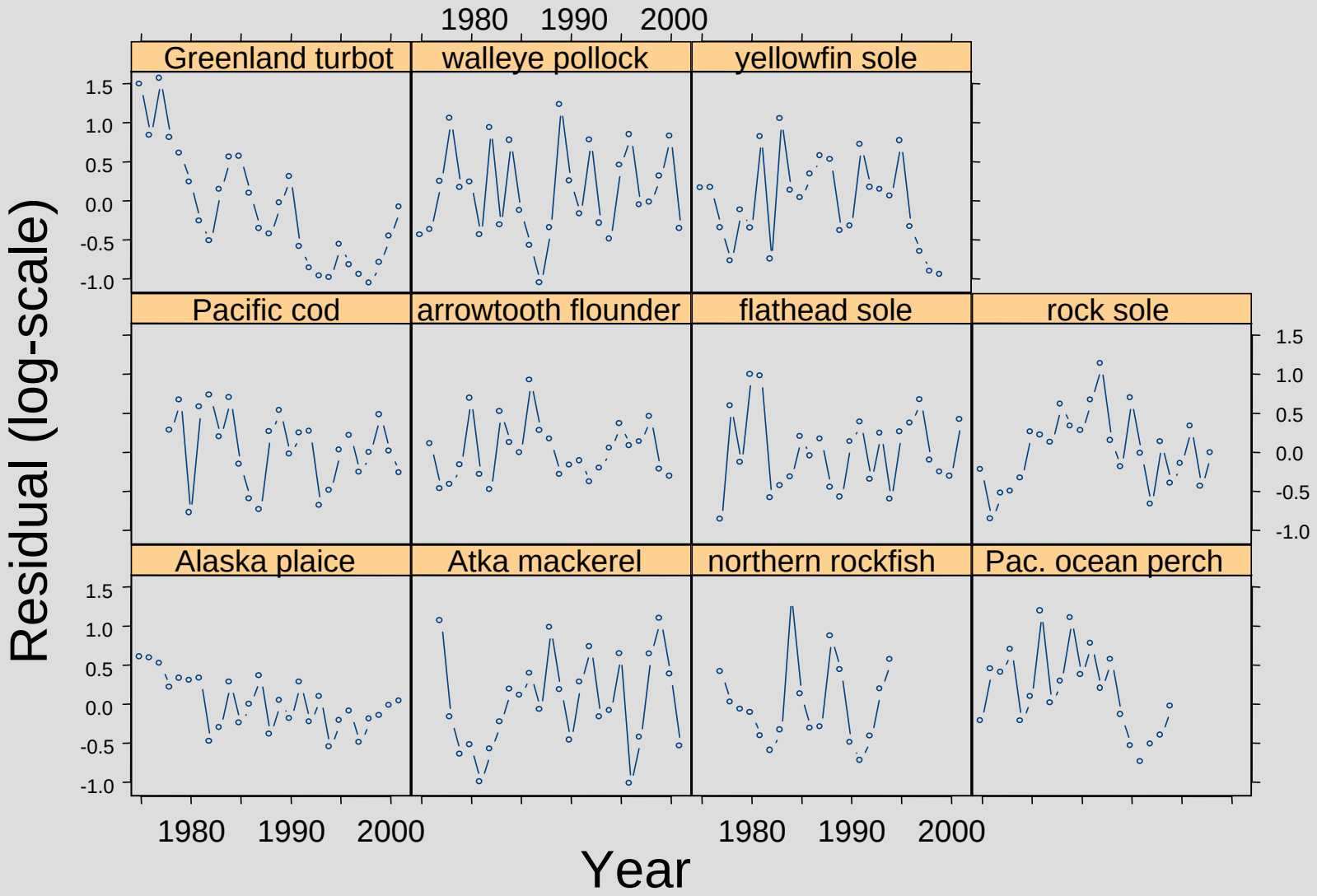
Distribution of pairwise correlations among groundfish stocks and salmon / herring stocks



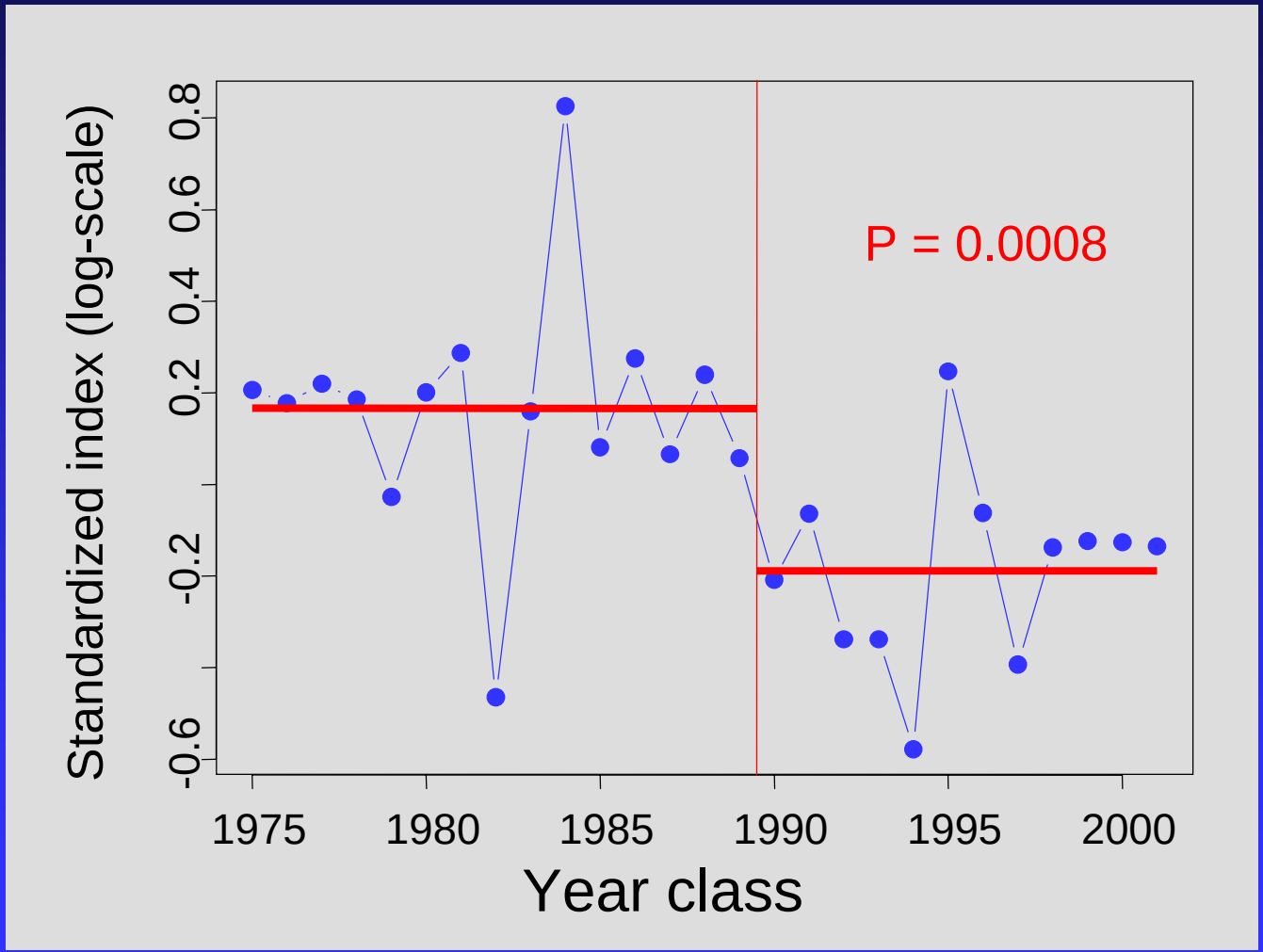
Temporal scales and patterns of variability in productivity

- Interannual vs. decadal-scale variabililty
  - On average < 30% of overall variability in productivity due to “decadal-scale” trends
  - Linear trends in productivity (1970-present):
    - 10 of 28 groundfish stocks: 9 with decreasing trend
    - 7 of 14 salmon stock groups: 6 with increasing trend
- Evidence for regime shifts
  - salmon stocks: 1976/77
  - groundfish stocks: 1988/89

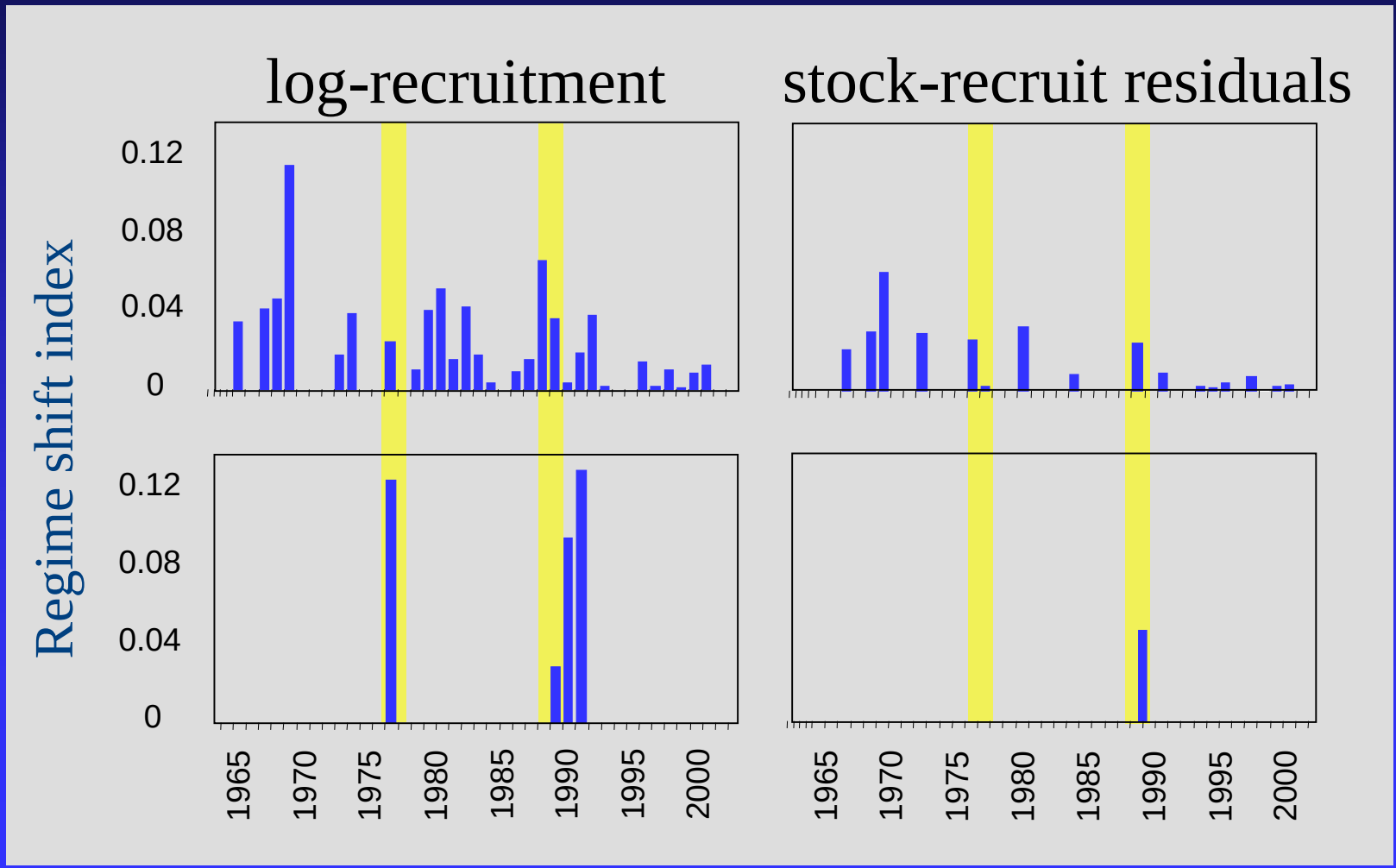
Species-specific stock-recruit residuals (Bering Sea)



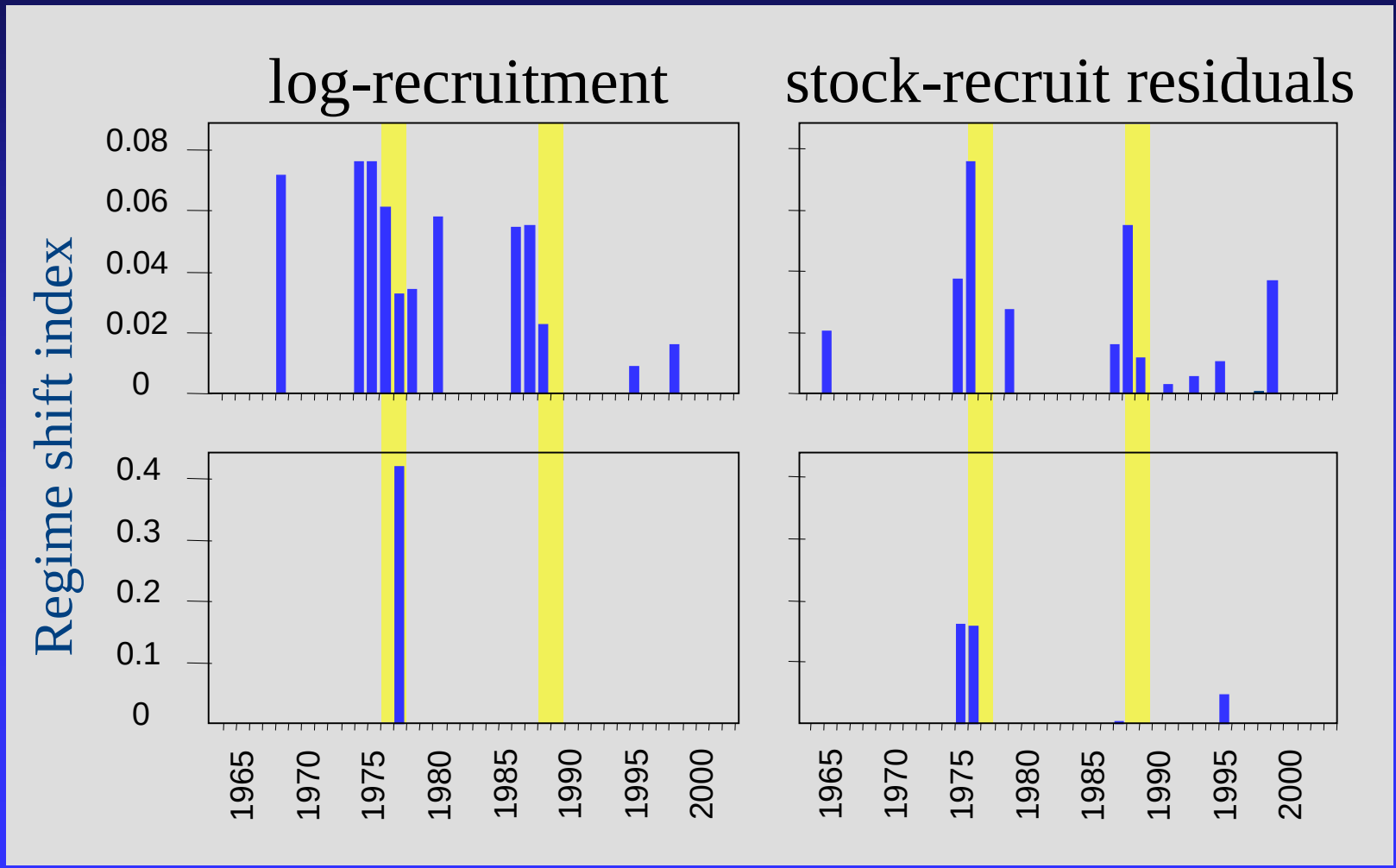
Bering Sea groundfish: aggregated stock-recruit residuals



Regime shifts: groundfish stocks



Regime shifts: salmon stocks



Summary and conclusions: Spatial covariation in productivity

- Regional-scale covariation among measures of productivty:
  - salmon stocks (up to ~ 1000km)
  - herring stocks (up to ~ 1000km)
  - groundfish stocks (within large ecosystems)
    - both positive and negative

→ **Environmental forcing affects many stocks and species in similar (or opposite) ways**

→ **Environmental processes at regional scales of several 100 to 1000 km most important in driving variability in fish productivity**

Summary and conclusions: Spatial covariation in productivity

- No covariation across “basin-wide” scales

→ **Need to link large-scale measures of environmental variability to regional-scale mechanisms**

- No covariation between pelagics (salmon / herring) and groundfish

→ **Different factors / processes drive productivity**

Summary and conclusions: Temporal patterns

- High interannual variability dominates productivity of individual stocks
- Regime-like behaviour largely emerges at aggregate levels

→ **System-level constraints on overall productivity?**

- Increase in productivity of both salmon and groundfish after 1976/77
- Decrease in productivity of groundfish (but not salmon) after 1988/89

→ **Different response to 88/89 regime shifts**

Conclusions

- Key question: “At what spatial and temporal scales are physical processes most important in affecting marine fish populations?”

“Regional” spatial scales <u>most</u> important

Interannual time scale most important for individual stocks and species

Larger spatial scales and decadal time scales (regime shifts) important to total productivity

Combined recruitment indices